EAR PLUG WITH SURFACE ELECTRODES

RELATED APPLICATIONS

The present application is a continuation-in-part of application PCT/DK2010/050174, filed on Jul. 1, 2010, in Denmark and published as WO2011000383 A1.

The present application is a continuation-in-part of application PCT/DK/2009/050156, filed on Jul. 2, 2009, in Denmark and published as WO 2011000375 A1.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to ear plugs. More specifically, the present invention relates to an ear plug comprising a shell with at least two electrodes adapted for measuring brain wave signals, said electrodes being connected with means for processing the measured signals. The invention further relates to a method of producing an ear plug.

It is generally known, particularly within medical science, to measure brain waves by placing electrodes on the scalp of a subject, whose brain waves it is desired to measure (for simplicity denoted "subject" in the following), and to view, process and interpret the measured brain waves using suitable equipment. Typically, such equipment is an electroencephalograph, by means of which a so-called electroencephalogram (EEG) may be achieved. The EEG is obtained by a measurement and recording of electrical activity in a subject's brain by measuring the electric potential generated on the surface of the subject's scalp by currents flowing between dendrites in the subject's brain. Within medical science EEG's are used for various diagnostic purposes.

2. The Prior Art

A system for such a use is known from WO-A1-2006/047874, which describes measurement of brain waves by use of electrodes placed in connection with at least one of the ears of the subject, i.e. placed on an outer ear part or placed in the ear canal. The measurements are used particularly for detecting the onset of an epileptic seizure. WO-A1-2006/047874 also describes the use of electrodes in pairs as detection and reference electrodes respectively, such a setup being well known in the field of electroencephalography.

Furthermore it is known from WO-A1-2008/116462 to measure the hearing ability of the subject by using a hearing aid to generate a test stimulus signal and transmit said signal to a subject as an acoustic stimulus, and by detecting a brain wave response to said acoustic stimulus signal by use of separate electrodes placed on the subject's scalp and transmitting the brain wave response to an electrophysiological instrument such as an electroencephalograph for processing.

WO-A1-2007/047667 describes an ear plug for measuring EEG-signals. The ear plug comprises an exterior shell with electrodes, the shell being made of a soft, compressible material, such as memory foam, capable of conforming to the interior of an individual's auditory canal. The signals obtained with the ear plug are transmitted to external units for processing and monitoring.

However, at least the signal processing devices of the known systems are, due to their complexity and use of extensive and complicated equipment, confined to use and operation by qualified staff. Furthermore the placement of in by far most cases electrodes and in any case associated wiring on various parts of the subject's scalp and/or head renders the known systems rather unattractive for use outside laboratory surroundings, thus rendering exploitation of the advantages related to the use of brain wave measurements outside the laboratory, e.g in everyday use, rather cumbersome.

With the ear plug according to WO-A1-2007/047667 a solution to the problem regarding the electrodes is proposed. However, several disadvantages remain. There is a risk of insufficient contacting between the ear canal and the electrodes due to the shell, which again may cause poor or insufficient signal quality. Also, the shell properties imply a low durability of the proposed ear plug. Furthermore, it is well known, that ear plugs of the type proposed in WO-A1-2007/047667 cause an enlarged risk of the user suffering from occlusion and/or insufficient ventilation of the ear canal, particularly during long term use.

SUMMARY OF THE INVENTION

The present invention therefore aims at providing an ear plug by means of which ear plug electrical brain wave measurements such as EEGs become possible without or with a minimum of use of extensive and complicated equipment, which ear plug may be used in an uncomplicated way in everyday life while obtaining high quality brain wave signals, and with which the advantages related to the use of brain wave measurements may be readily utilized outside the laboratory.

The invention in a first aspect provides an ear plug comprising a shell with at least two electrodes adapted for measuring brain wave signals, said electrodes being connected with means for processing the measured signals, wherein in that the contours of the outer surface of the ear plug are individually matched to at least part of the ear canal and the concha of the user, and wherein the ear plug is made of a dimensionally stable material for identical positioning in the ear canal each time it is inserted.

This ear plug obtains an improved contact between the user's ear canal and the electrodes and a very high degree of repeatability in the placement of the electrodes between individual measurement sessions, in that the ear plug due to being individually matched will be positioned identically in the ear canal each time it is inserted. Thereby measurement uncertainties related to quantitative and qualitative variations due to changed electrode positions or insufficient contact may substantially be avoided.

As the ear plug according to the invention is individually matched, it comprises surface convexities matching the concavities of the specific ear canal of the specific user to whom the plug is individually matched. This has several advantages. Firstly, there is one correct position of the ear plug in the user's ear canal only, and thus the ear plug is easy to insert, and it is easy to determine when it is in its correct position. Secondly, the right and left ear plugs cannot be confused as each ear plug matches one specific ear canal. Furthermore, the ear plug according to the invention is firmly secured in the ear canal of the user substantially by friction alone, and produces no static pressure against the skin of the ear canal. Consequently, the ear plug according to the invention is very well suited for long term use, e.g. for use during the night, as the long term inconveniences caused by the static pressure against the skin of the ear canal in conventional ear plugs are eliminated. Also, the ear plug according to the invention is very well suited for use by children and other persons who cannot insert the plug into their ear canal themselves, as the plug is very easy to insert and as it is easy for an assisting person to determine when the plug is in proper place. Also, the ear plug according to the invention will not fall out of the ear canal during physical activity.

Individually matched ear plugs are widely known and used within the hearing aid industry as a completely-in-canal